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Functional Echo-Planar MR Imaging at 1 T

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Functional MR imaging (1) of the central nervous system has become feasible with echo-planar imaging (EPI). Most applications have been shown at high field strength ($\geq$ 1.5 T). Despite the fact that the EPI prototype MR imager operates at medium field strength (1.0 T), it has been possible to measure cerebral blood flow, perfusion, and diffusion in patients and volunteers. Different appoaches have been used. Perfusion can be measured in Gd-DTPA time course studies by observing susceptibility-related signal drop. Mapping of blood-brain barrier (BBB) permeability is possible by evaluating signal increase after initial bolus passage in areas where the BBB is compromised. With multisection sequences, 3D maps can be obtained. The use of deoxyhemoglobin, rather than Gd-DTPA, as a natural contrast agent has recently been investigated. Long TE (> 180 msec) EPI sequences can be used for detection of hemoglobin saturation and related cerebral signal intensity changes. Principal component analysis is used regularly for evaluation of these dynamic studies. The feasibility of imaging (at 1.0 T) brain function, as in the optical cortex during optical stimulation, is currently being investigated. The potential and limitations of EPI and of the specific problems that have been encountered will be discussed.

1. Stehling MK, et al. Echo-planar imaging: magnetic resonance imaging in a fraction of a second. Science, October 1991.

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Functional MR Imaging of Primary Visual and Motor Cortex

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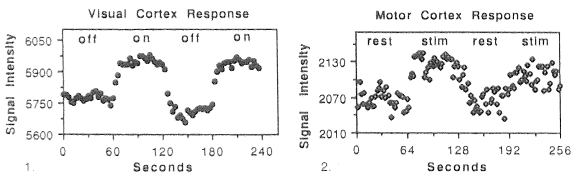
High-speed, noninvasive MR imaging methods sensitive to changes in cerebral blood flow, blood volume, and oxygenation have been used to generate functional MR imaging maps of human visual and motor cortex activation. These MR imaging techniques provide high spatial and temporal resolution information and can be used to correlate behavioral and physiologic changes with underlying anatomy. Seven healthy subjects underwent dynamic MR imaging with a modified echo-planar imaging technique (1.5 T, GE Signa, modified by Advanced NMR Systems). Changes in blood oxygenation were detected with a gradient-echo (GE) imaging sequence sensitive to variations in T2* (TR = 3,000 msec, TE = 40 msec). Changes in tissue perfusion were evaluated with a spin-echo inversion recovery (IR), T1-sensitive pulse sequence (TI = 1,100 msec, TR = 3,500 msec, TE = 42 msec). Typically a series of between 80 and 128 images were acquired continuously with the same imaging pulse sequence (either GE or IR). Figure 1 shows signal intensity changes as a function of time for a region of interest within primary visual cortex during darkness and during 7.8-Hz photic stimulation. Figure 2 displays signal intensity changes within primary motor cortex during repetitive hand movements and during resting state.



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Echo-Planar Imaging of Cerebral Capillary Percent Deoxyhemoglobin Change on Task Activation

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It is well known that cerebral metabolism and blood flow are enhanced during the activation of regions of the cerebral cortex involved in the performance of specific tasks. It has also been demonstrated that induced local increase of cerebral blood flow exceeds concomitant local increase in tissue metabolic rate, causing a significant decrease in the oxygen extraction fraction (1), and thus a decrease in %deoxyhemoglobin (Hb). The paramagnetic character of deoxy-Hb has been extensively studied in vitro (2) and in larger vessels (3,4). The hypothesis is that capillary deoxy-Hb causes a bulk susceptibility differential between each capillary and the surrounding tissue, setting up microscopically inhomogeneous static fields that cause a net intravoxel dephasing of spins. On cerebral tissue activation, the local decrease in %deoxy-Hb causes a decrease in the susceptibility differential between capillary and tissue, thus decreasing intravoxel dephasing and allowing increased signal in a gradient-recalled sequence. The observed change in signal corresponds closely with the change in signal predicted by a simulation correlating normalized voxel signal intensity with known physiologic parameters of capillary size, density, geometry, and oxygen extraction fraction; and the empirical relationship between bulk susceptibility, %deoxy-Hb, and field strength for various capillary orientations and blood hematocrits. The recently introduced imaging protocol, which observed activation of the visual cortex during photic stimulation (5,6), involved collecting a series of axial gradient-recalled echo-planar images. That method has been expanded on by the imaging of task activation centers in all three planes. With use of a local head xyz gradient coil of original design fitted to a GE Signa 1.5-T magnet, sets of 128 coronal, axial, and sagittal gradient-recalled echo-planar images of the brain (TE = 50 msec, TR or image spacing of 2,000 msec) were obtained in seven subjects. At image number 64, the subjects were instructed to begin the task of touching their thumb to each finger in a sequential manner. In each instance, an immediate (< 2,000 msec) increase of 3% to 9% in signal was observed in the cortical areas corresponding to the task. Also, in sets taken in which the subjects stopped the task at image number 64, an immediate decrease of 3% to 9% in the signal in the same cortical areas was observed. Echo-planar imaging of dynamic capillary %deoxy-Hb contrast is a powerful new tool for the flexible, noninvasive, and high-resolution assessment of regional cerebral activation.

1. Fox PA, Raichle ME. Proc Natl Acad Sci USA 1986; 83: 1140–1144. 2. Thulborn KR. Biochim Biophys Acta 1982; 714:265–270. 3. Ogawa S, Lee TM, Nayak AS, Glynn P. Magn Reson Med 1990; 14:68–78. 4. Wright GA, Hu BS, Macovski A. JMRI 1991; 1:275–283. 5. Brady TJ. SMRM Book of abstracts 1991; 1:2. 6. Hoppel BE, Weisskoff RM, Thulborn KR, Moore J, Rosen BR. SMRM Book of abstracts 1991; 1:308.